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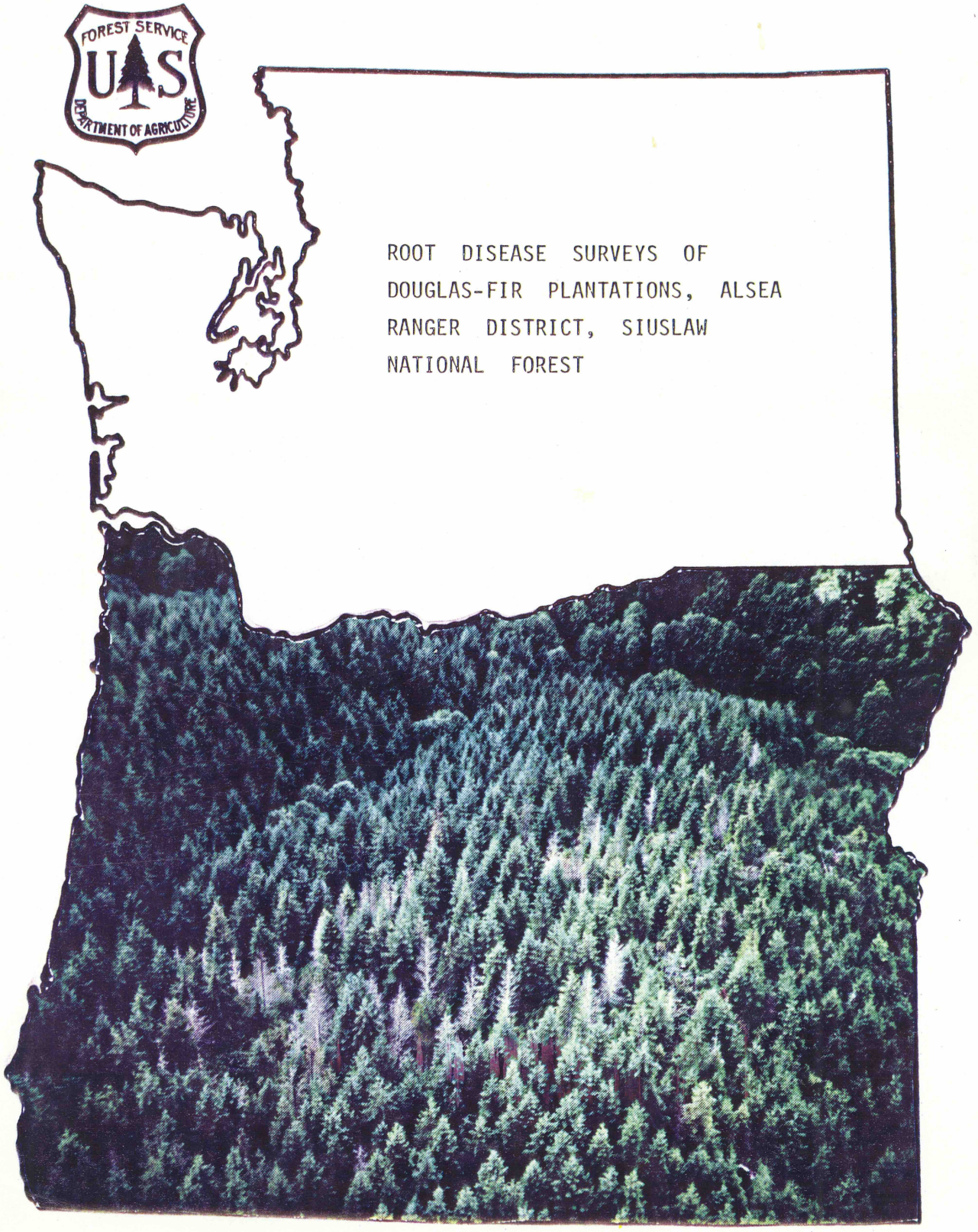
Forest Pest Management
Pacific Northwest Region



ROOT DISEASE SURVEYS OF DOUGLAS-FIR PLANTATIONS, ALSEA RANGER DISTRICT, SIUSLAW NATIONAL FOREST

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INTRODUCTION

During the summer and fall of 1983, forest pest surveys were done in 82 Douglas-fir plantations (totaling about 4,400 acres) on the southern part of the Alsea Ranger District, Siuslaw National Forest. Past surveys had shown that particularly severe laminated root rot (caused by the fungus *Phellinus weirii*) affects many older stands in the area. By virtue of their locations, it was feared that 15- to 25-year-old plantations interspersed with these older stands might also have substantial amounts of root disease. The District requested the present evaluation to assess pest conditions in plantations and provide management recommendations to minimize future losses in those with pest problems.

METHODS

Aerial Survey - In the first stage of the evaluation, all 82 plantations were inspected from a Bell 205 Jet Ranger helicopter. Each plantation was flown over at low levels (500-1,000 feet). When necessary to get complete coverage, several passes were made over individual units. The aerial surveyor examined the stand and assigned it a mortality rating based on apparent percentage of trees dead or dying: (1) light or no mortality (0-10%), (2) moderate mortality (11-25%), or (3) severe mortality (26% or more). In addition, if there were discrete areas of mortality in a plantation, they were delineated on a sketch map of the unit.

Ground Survey - A subsample of 15 plantations (2 that had been classified from the air as having severe mortality, 6 that had been classified as having moderate mortality, and 7 that had been classified as having light or no mortality) were randomly selected and surveyed intensively on the ground. Purposes of this stage of the evaluation were to test the accuracy of the aerial mortality rating estimates and determine identity of pests causing tree killing in plantations. In each unit, plots were located at two-chain intervals along four equally spaced transects that were run completely across the plantation. At each plot, the three closest crop trees were examined and tallied by condition. On all dead or symptomatic trees, two roots on opposite sides were excavated to a distance of 3 feet from the root collar and examined for stain, decay, or mycelia. Stems and crowns of all trees were also examined for evidence of injuries, disease, or insect infestation.

RESULTS AND DISCUSSION

Surveyed plantations were composed mostly of Douglas-fir (*Pseudotsuga menziesii*). Lesser amounts of western hemlock (*Tsuga heterophylla*) and western redcedar (*Thuja plicata*) occurred in some stands. Most plantations had been precommercially thinned and most were on high quality sites. As expected, many plantations were being affected by forest pests, and mortality was quite visible from the air (Figure 1).

Based on the aerial survey, 52 percent of the plantations fell in the light or no mortality class, 38 percent in the moderate mortality class, and 10 percent in the severe mortality class (Table 1). Results of the ground surveys (Table 2) indicated that the aerial ratings were quite accurate. All units examined received the same rating on the ground that they did from the air. Also, the ground surveys showed that virtually all mortality in the units was caused by root diseases. By far the commonest pathogen was *P. weirii*, but *Ceratocystis wageneri*, cause of black stain root disease, was also detected in some plantations. *C. wageneri* usually was found affecting small numbers of trees directly adjacent to roads while *P. weirii* was distributed widely throughout units. When dead trees (Figure 2) were examined, *P. weirii* was detected easily by excavating roots and observing the white to gray, crusty ectotrophic mycelia of the fungus on the bark (Figure 3). Setal hyphae usually could be found scattered in the ectotrophic mycelia. *C. wageneri* was detected by chopping into the sapwood of the root collar and roots of infected trees and exposing the diagnostic purple-brown to black stain (Figure 4). The following is a more detailed discussion of the diseases caused by the two pathogens.

Black Stain Root Disease - Black stain is not a root rot. Rather, it is more similar to such vascular wilt diseases of hardwoods as Dutch elm disease and oak wilt. The hyphae of *C. wageneri* grow into the host's tracheids plugging them and interfering with water uptake and transport. Infection usually results in rapid tree decline and death. In western Oregon, *C. wageneri* only infects Douglas-fir and is most frequently found in young plantations (under 30 years old).

C. wageneri is vectored over long distances by root feeding weevils and bark beetles. These insects prefer low-vigor hosts. Thus, new infections are usually initiated in roots of weakened trees. In Oregon, black stain is most common where site conditions foster poor tree vigor or where there are many injured trees. It is especially common and can sometimes be quite damaging in areas where soils have been severely compacted as a result of tractor logging on fragile sites. It is also common along roads where trees have been injured in maintenance or partially covered by fill.

Once *C. wageneri* is established in a tree, it can infect adjacent trees, irrespective of vigor, across root grafts or contacts. It spreads rather rapidly (4-6 feet per year). *C. wageneri* dies with its hosts. Therefore, active infection centers require a continuous network of living host roots for the fungus to invade as previously infected trees die.

Based on currently observed levels of disease and on the type of management being practiced on the Alsea District, black stain probably does not pose too serious a threat in the area. Control of the disease is best attained through minimizing potential for new infection center establishment by avoiding tree injury and by not creating the type of site conditions that favor the disease. In an already established center, the disease can be controlled by cutting all hosts in the center and a 50-foot buffer around it. The opening created can be replanted immediately with nonhosts (anything but Douglas-fir) or can be replanted with Douglas-fir when all roots of the former trees are dead (at least one year after cutting).

Laminated Root Rot - Laminated root rot is a classic root decay disease. It rots the host's root system extensively, either causing the tree to be windthrown or killing it by destroying its ability to take up water and nutrients. *P. weirii* is an especially dangerous pathogen, not only because of its devastating effects on infected trees, but because it is persistent on the site. The fungus can survive for long time periods (up to 50 years) in roots of old stumps and infect new hosts that become established on the site via root contacts. Infection centers then develop and increase in size due to spread from tree to tree along roots. Rate of spread is about one foot per year. Laminated root rot does not exhibit preference for any particular site conditions. It is likely to occur on any kind of site found in the Pacific Northwest, and is particularly damaging on very good sites.

P. weirii can infect all conifer species. However, some show a great deal more resistance to the pathogen than others. In the Alsea area, Douglas-fir is highly susceptible (readily infected and killed), western hemlock is intermediately susceptible (frequently infected but rarely killed), and western redcedar is resistant (rarely infected and almost never killed). All hardwoods are immune to *P. weirii*.

In West Side forests with steep topography, the recommended control for laminated root rot is to cut all susceptible trees in each infection center and a 50-foot buffer around it and replant the area with immune, resistant, or intermediately susceptible tree species. Use of immune or resistant tree species in replanting has the advantage of allowing managers to return to Douglas-fir in subsequent rotations since all or most of the *P. weirii* inoculum will probably die out. However, intermediately susceptible species may provide a better economic return. Forest Pest Management has developed a framework for economic analyses of root rot control that may be useful in making the determination of which alternative species to plant (Filip and Wiitala in preparation). It must be recognized that, if intermediately susceptible species are planted on a diseased site, there will be very little decrease in *P. weirii* inoculum over a rotation and replanting with Douglas-fir in the next rotation would be extremely ill advised.

Laminated root rot, unlike black stain, is currently causing considerable losses in the Alsea plantations and has the potential to be even more damaging in the future. Almost half of the plantations surveyed have moderate or severe levels of mortality with 11 to a phenomenal 51 percent of the trees already affected. Furthermore, the widely scattered, general distribution of mortality in many plantations is very disturbing. After a plantation is established on a diseased site, it usually takes 10 to 15 years for the roots of the planted trees to contact the roots of old colonized stumps and themselves become affected to the degree that crown symptoms are produced. Well-defined infection centers resulting from subsequent root-to-root spread may take an additional 10 to 15 years to become evident. In most of the plantations examined in this evaluation, *P. weirii* infection centers are just beginning to develop, and much of the mortality now being seen involves individual trees very close to old infected stumps. The wide distribution of mortality now being observed indicates that inoculum is probably distributed over most of the area in many plantations with moderate or severe mortality ratings. Thus, there is a particularly great danger of young trees throughout these plantations being exposed to infection in the 20 to 40 additional years that would be required to bring these stands to normal rotations. Mortality losses could be horrendous (70 to 90 percent of the trees) in plantations already showing severe disease. Without treatment, the same kind of losses would probably also continue or even increase in following rotations.

MANAGEMENT RECOMMENDATIONS

We believe that limiting damage caused by laminated root rot should be a critical concern of the Alsea District. The following specific management recommendations are made for plantations examined in this evaluation:

(1) Plantations with Severe Mortality Ratings - Destroy these stands immediately and treat by replanting with tree species intermediately susceptible (western hemlock), resistant (western redcedar), or immune (hardwoods) to *P. weirii*. If western hemlock is employed, do not consider reestablishing Douglas-fir in the following rotation.

(2) Plantations with Moderate Mortality Ratings - Carry these plantations until trees reach minimum merchantable size. Between now and then, do not carry out any intermediate treatments that require capital outlay. Clearcut stands, and treat sites by replanting tree species intermediately susceptible, resistant, or immune to *P. weirii*. Reestablish Douglas-fir only after a rotation of resistant or immune tree species.

(3) Plantations with Light or No Mortality - Manage these stands in the normal fashion with the following modifications: (a) If any of these stands have not yet been precommercially thinned, incorporate disease management considerations in this process. Favor naturally occurring western hemlock and western redcedar in portions of the stands with scattered Douglas-fir mortality. If there are distinct pockets of dying trees, cut all Douglas-firs in each pocket and in a 50-foot buffer around it and replant openings with hemlock, cedars, or hardwoods; (b) At the time of commercial thinning, harvest Douglas-firs in and within 50 feet of any obvious *P. weirii* infection centers. Map location of centers and keep data concerning location in unit records; (c) Just before final harvest, reexamine the stands and map any *P. weirii* infection centers not already on record. After harvest, treat infected areas and a 50-foot buffer around each by replanting with hemlock, cedar, or hardwoods. Replant the remainder of the stand with Douglas-fir.

Table 1: Mortality ratings of plantations surveyed from helicopter in Alsea survey.

TRI Cell	Area (Acres)	Disease Rating	Additional Notes
3502-3A2	74	M	Scattered mortality; most intense on south central ridge
3502-4B2	78	M	Scattered mortality throughout
3502-6C2	75	L	Little mortality
3502-7A3	44	L	Light scattered mortality
3502-8	?	L	Light scattered mortality; worst along road to south
3502-10A3	90	L	Most mortality along road
3502-12B3	67	M	Mortality scattered throughout; worse to west
3502-13B4	65	M	Mortality scattered throughout
3502-14B3	15	L	Little mortality
3502-20	?	M	Scattered mortality throughout
3502-22C3	37	L	Light scattered mortality
3502-23D3	31	L	Little mortality
3502-25D4	62	M	Scattered mortality throughout
3502-26D4	29	L	Most mortality along road
3502-27D4	32	L	Most mortality along road
3502-28D4	29	M	Scattered mortality throughout
3502-29C2	10	M	Scattered mortality throughout
3502-30D4	46	M	Scattered mortality throughout
3502-34B3	5	L	Little mortality
3502-122C4	37	M	Scattered mortality throughout
3502-160C4	141	M	Scattered mortality throughout

Table 1: Mortality ratings of plantations surveyed from helicopter in Alsea survey. (Continued)

TRI Cell	Area (Acres)	Disease Rating	Additional Notes
33503-4D4	118	S	Mortality throughout stand; lots at roadside
3503-5D4	38	M	Mortality throughout; worse on eastern third
3503-6D2	95	S	Severe mortality throughout
3503-7D1	4	L	Little mortality seen
3503-8D1	68	M	Band of mortality across center of stand
3503-9D4	90	L	Light scattered mortality
3503-10E4	48	M	Scattered mortality throughout
3503-11C1	58	M	Intense areas of mortality on ridges center and east part of unit
3503-13C2	143	M	Most mortality along ridges in center and south part of unit
3503-14C2	36	M	Scattered mortality; intense area along skid road in west center
3503-15C2	12	M	Scattered mortality in eastern half
3503-16D2	70	L	Scattered mortality most intense along eastern border
3503-18C2	14	M	Most mortality south of road
3503-19E1	70	M	Scattered mortality throughout
3503-20D1	104	M	Scattered mortality throughout, worse in northwest corner and center
3503-21D4	16	L	Light scattered mortality
3503-22B2	29	M	Mortality scattered throughout
3503-23D4	13	L	Little mortality
3503-24E4	46	L	Light scattered mortality
3503-25B2	80	L	Scattered mortality in Southwest; 1 intense pocket in northwest center
3503-27D4	78	S	Mortality throughout; severe patches in north center & southwest corner
3503-28C3	57	S	Mortality throughout; lots along road
3503-30C2	61	L	Light scattered mortality

Table 1: Mortality ratings of plantations surveyed from helicopter in Alsea survey. (Continued)

TRI Cell	Area (Acres)	Disease Rating	Additional Notes
3503-31E4	23	M	Mortality scattered throughout
3503-34D3	22	L	Little mortality seen
3504-2D1	99	M	Scattered mortality in eastern part of stand; intense areas in northwest corner and along western boundary
3504-6D1	48	M	Mortality scattered throughout; intense area along road to north
3504-7D1	73	S	Mortality scattered throughout; intense in center of unit
3504-9D2	36	M	Mortality throughout but worse north of road
3504-10C2	51	M	Intense areas of mortality in center and northwest corner of unit
3504-13C2	96	M	Intense areas of mortality in southwest corner and east center of unit
3504-18A1	27	L	Most mortality on ridge to west
3504-20A1	41	L	Most mortality along road
3504-24	?	M	Intense area of mortality along southern boundary
3504-25B2	52	L	Light mortality mostly along road at west and northern boundary
3504-27B3	34	L	Light scattered mortality
3504-35C2	23	L	Light scattered mortality; intense area in northwest corner
3504-36D2	68	L	Little mortality
3504-37D3	68	L	Scattered light mortality mostly along west central boundary and road to south
3504-40C3	68	L	Sparse stocking, light scattered mortality
3504-45C4	43	L	Light scattered mortality
3504-46C4	63	L	Scattered mortality, most intense along road in southwest corner
3504-47C5	27	L	Scattered mortality, one intense pocket in west center of unit

Table 1: Mortality ratings of plantations surveyed from helicopter in Alsea survey. (Continued)

TRI Cell	Area (Acres)	Disease Rating	Additional Notes
3505-1C1	34	L	Most mortality along road to south
3505-2C1	62	M	Scattered mortality, worse in northeast half
3505-4C1	62	L	Light scattered mortality
3505-5B2	92	L	Little mortality
3505-10C2	69	M	Scattered mortality throughout, worse on ridge top
3505-12C2	51	L	Light scattered mortality
3505-15B2	18	S	Mortality severe throughout
3505-17B3	102	S	Mortality severe throughout; most intense along north boundary and in south east corner
3505-18B3	74	L	Light scattered mortality
3505-19B3	34	S	Mortality severe throught
3505-20C3	55	L	Scattered mortality, intense area above road in east
3505-21C3	51	L	Little mortality
3505-22D4	110	L	Scattered mortality, worse on east boundary
3505-23C4	74	L	Very little mortality
3505-24D4	51	L	Light scattered mortality
3505-25C5	80	L	Light scattered mortality
3505-26B5	49	L	Light scattered mortality
3505-27B5	33	L	Light scattered mortality

Table 2: Results of ground surveys in sample of randomly selected units in Alsea evaluation, and comparison between ground and aerial ratings.

TRI Cell	Area (Acres)	Disease Rating from the Air	Disease Rating from the Ground	% Trees x Affected	Pests Involved *
3502-12B3	67	M	M	20	PW
3502-13B4	65	M	M	20	PW
3502-14B3	15	L	L	1	PW, A
3503-4D4	118	S	S	30	PW
3503-7D1	4	L	L	3	PW
3503-10E4	48	M	M	23	PW
3503-21D4	16	L	L	7	PW
3503-23D4	13	L	L	1	PW
3505-31E4	23	M	M	19	PW, CW
3503-34D3 †	22	L	L	0	...
3504-9D2	36	M	M	11	PW
3504-35C2	23	L	L	8	PW, CW
3505-15B2	18	S	S	51	PW, CW
3505-24D4	51	L	L	2	PW, CW, A
3505-26B5	49	L	L	6	PW, CW

x Crop trees (in these stands varying from 2 to 6 inches DBH and from 15 to 40 feet tall).

* PW = *Phellinus weirii* cause of laminated root rot.

CW = *Ceratocystis wageneri* cause of black stain root disease.

A = Animal damage.

† Ground checking showed that this plantation was much younger than other units surveyed (~10 years old).

Figure 1: Low level aerial view of laminated root rot-caused mortality in a young Douglas-fir plantation on the Alsea District.

Figure 2: On-the-ground view of a dead Douglas-fir in an Alsea plantation. Note distress cone crop and evidence of progressive growth decrease. Trees killed by either *P. weirii* or *C. wageneri* look like this.

Figure 3: Ectotrophic mycelia of *P. weirii* on exposed Douglas-fir roots. Occurrence of this mycelia is usually the best indicator of *P. weirii* infection on plantation-aged trees.

Figure 4: Diagnostic dark sapwood stain caused by *C. wageneri* in lower stem of infected Douglas-fir.

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